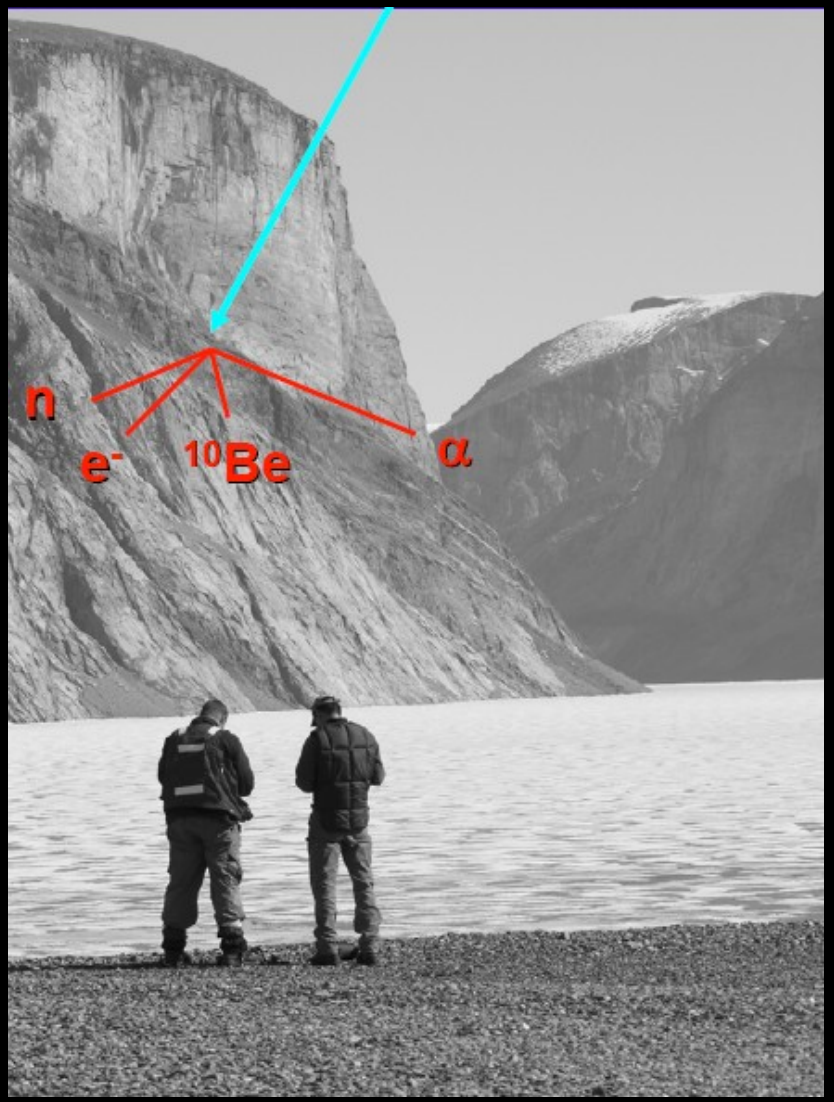
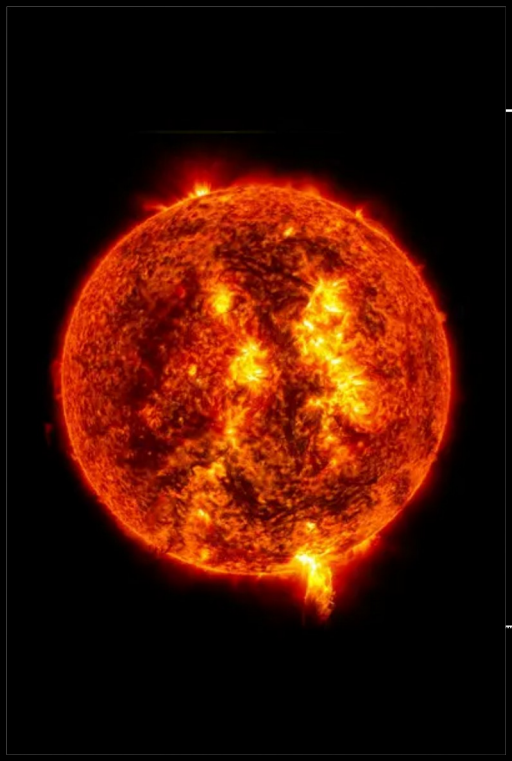
Descent into the LOREX rabbit hole

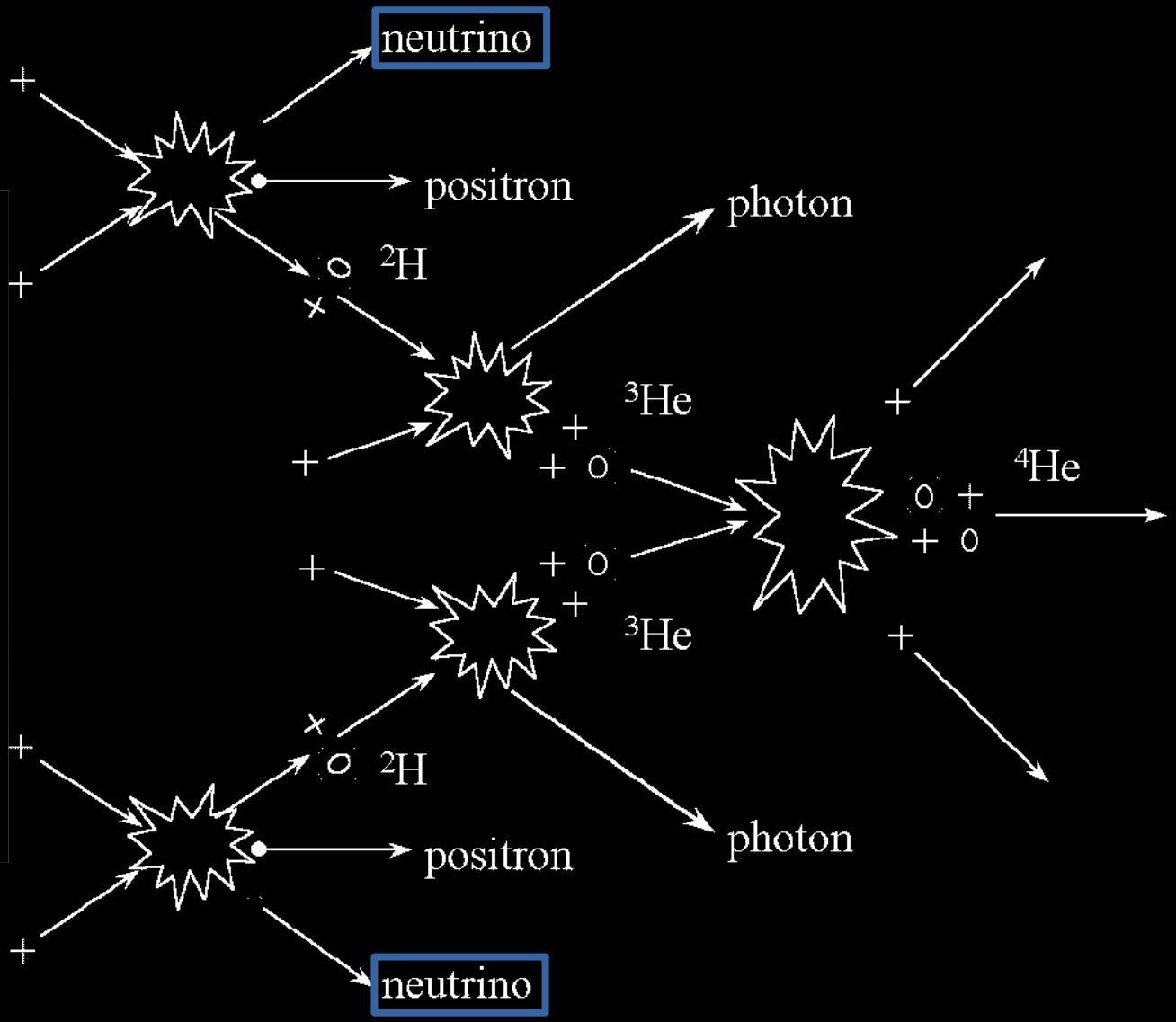
Pieter Vermeesch

p.vermeesch@ucl.ac.uk

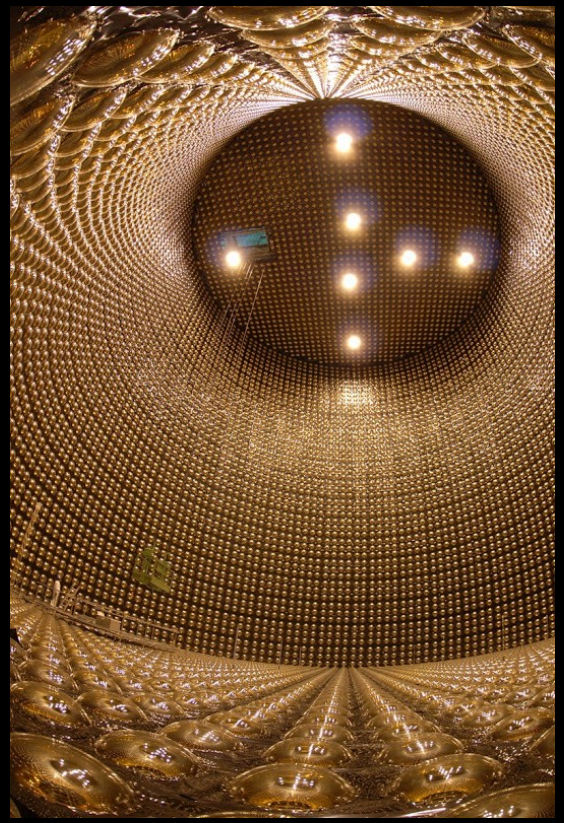


pp-reactions in the Sun produce neutrinos

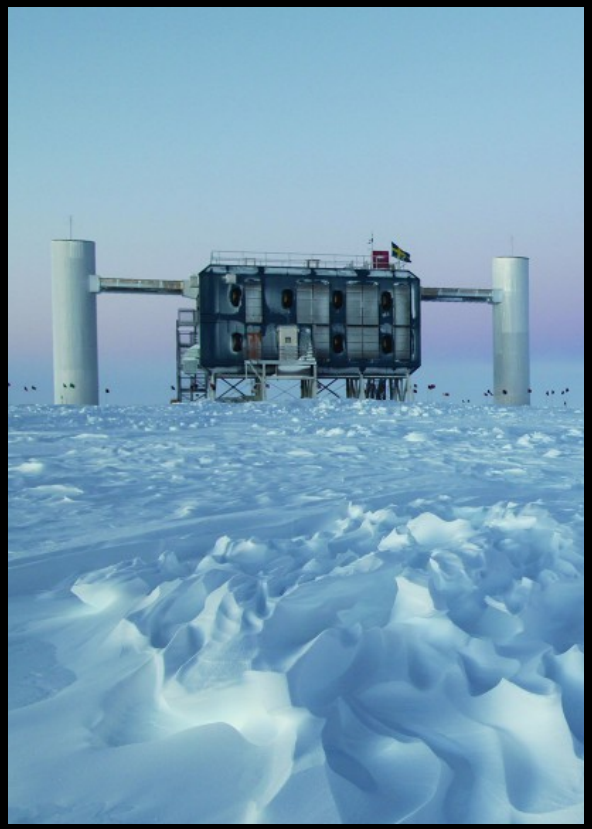




Borexino



Super Kamiokande



IceCube

Reports

Solar Neutrinos: Proposal for a New Test

Abstract. *The predicted flux on the earth of solar neutrinos has eluded detection, confounding current ideas of solar energy production by nuclear fusion. The dominant low-energy component of that flux can be detected by mass-spectrometric assay of the induced tiny concentration of 1.6 × 10^7 year lead-205 in old thallium minerals. Comments are solicited from those in all relevant disciplines.*

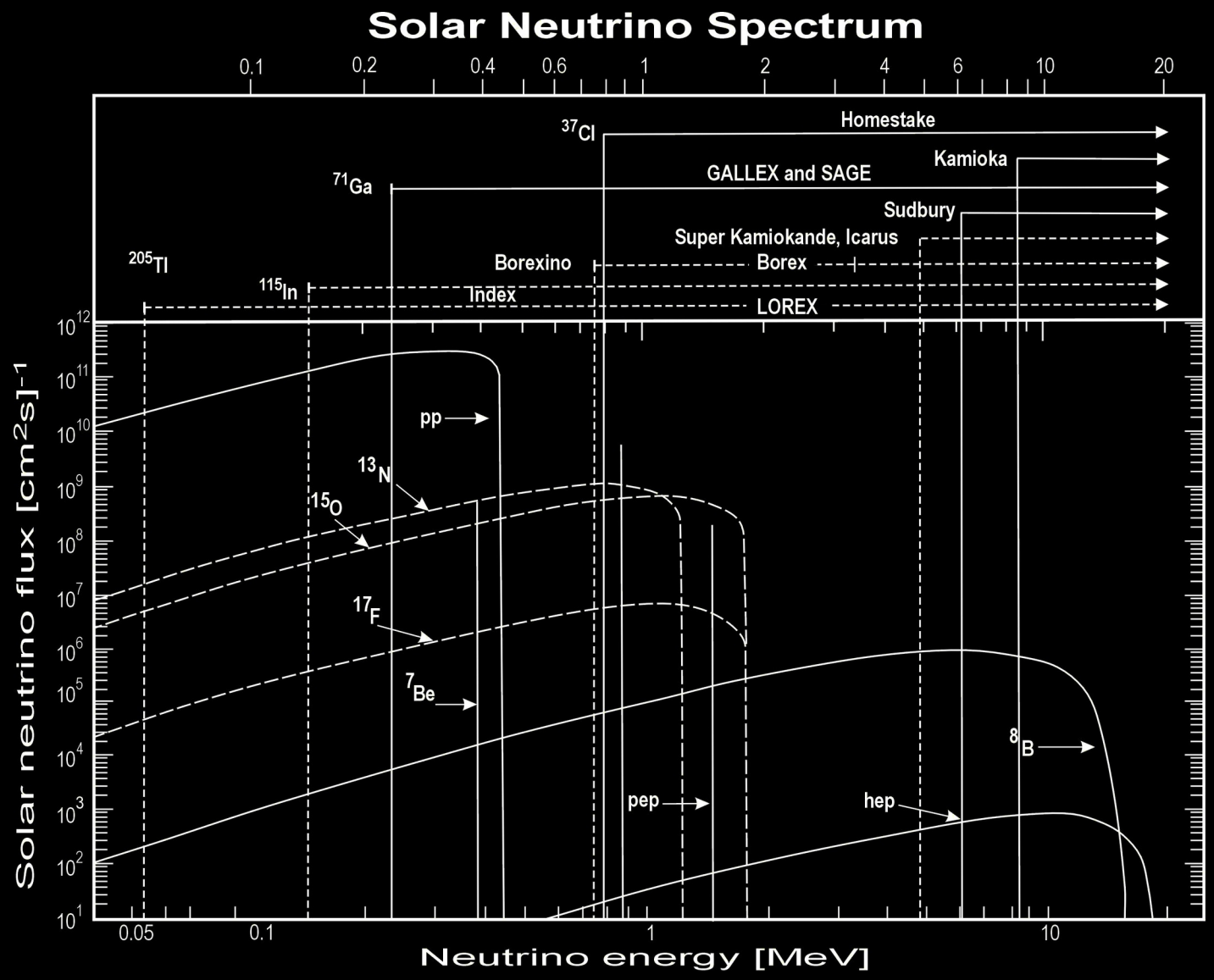
MELVIN S. FREEDMAN
CHARLES M. STEVENS
E. PHILIP HORWITZ
LOUIS H. FUCHS
JEROME L. LERNER
LEONARD S. GOODMAN
WILLIAM J. CHILDS
JAN HESSLER

Argonne National Laboratory,
Argonne, Illinois 60439

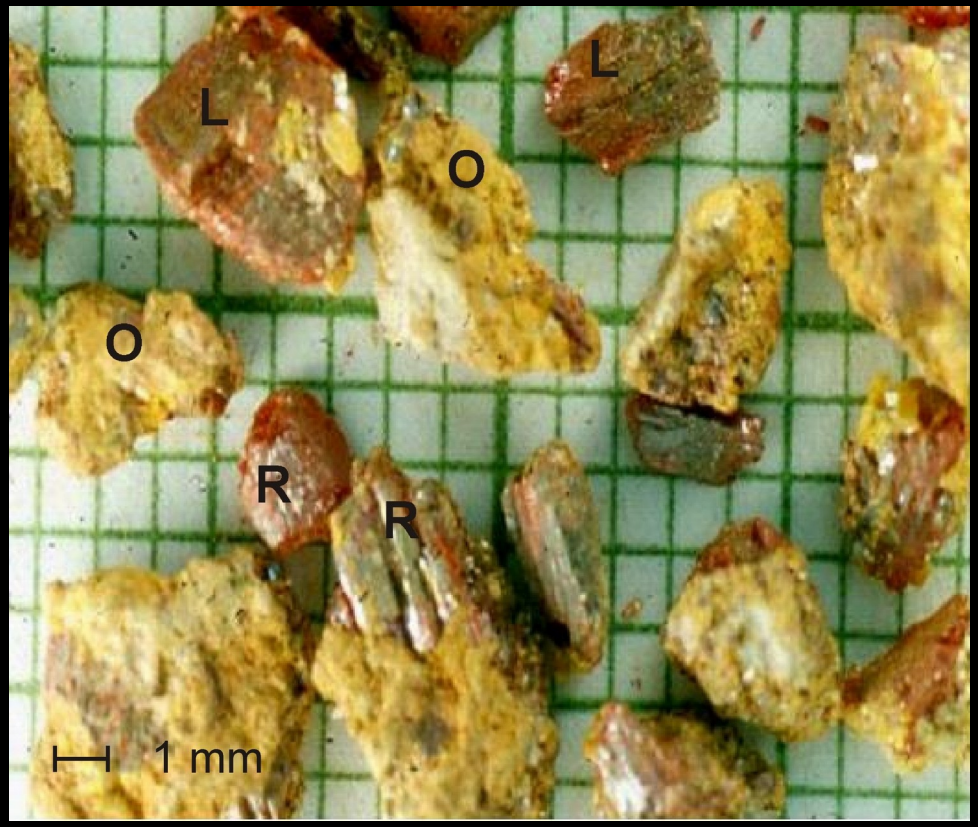
SCIENCE, VOL. 193

17 SEPTEMBER 1976

Thallium is sensitive to the widest range of neutrino energies



Lorandite ($TlAsS_2$), a geological neutrino detector



* Lorandite is a natural neutrino detector
* Allchar is the world's only lorandite mine

$$^{205}Tl\ (\nu_e, e^-)\ ^{205}Pb^* \rightarrow\ ^{205}Pb$$

The lorandite is old enough to be useful

$^{40}Ar/^{39}Ar$ dating of geological events of the Allchar deposit and its host rocks

F. NEUBAUER[1]*, M.K. PAVIĆEVIĆ[2, 3], J. GENSER[1], R. JELENKOVIĆ[4], B. BOEV[4] AND G. AMTHAUER[2]

[1]Div. Geology, University of Salzburg, Austria
(*correspondence: Franz.Neubauer@sbg.ac.at)
[2]Dept. Material Sciences, University of Salzburg, Austria
[3]Faculty of Mining and Geology, Belgrade, Serbia
[4]Fac. of Mining and Geology, University., Stip, Macedonia

Allchar is a Sb–As–Tl–Au deposit with an uncertain geodynamic setting located at the western part of the Vardar Zone, close to the border between Macedonia and Greece. Allchar is unique because of the abundant presence of the mineral lorandite ($TlAsS_2$). A total of 25 mineral concentrates from 18 samples has been measured with the $^{40}Ar/^{39}Ar$ method to examine the relationship between volcanism and secondary alteration associated with mineralization. Our results suggest that there is no relationship between volcanism and alteration/mineralization in the basement.

Experiments with amphibole from a subvolcanic latite body result in disturbed Ar release patterns and an age of 4.8 ± 0.2 Ma. Biotite yield slightly varying ages ranging between 4.6 ± 0.2 and 4.8 ± 0.2 Ma, K-feldspar disturbed, staircase patterns with ages increasing from 3.3 to 4.0 Ma. The mineral ages of the subvolcanic latite body are interpreted, therefore, to monitor rapid cooling from ca. 550-500°C (amphibole) through ca. ca. 300°C (biotite) to ca. 250 to 160°C (K-feldpar) between 4.8 and 3.3 Ma.

The biotite ages of 5.0 ± 0.1 and 5.1 ± 0.1 Ma from blocks of the Vitačovo tuff are geologically significant and

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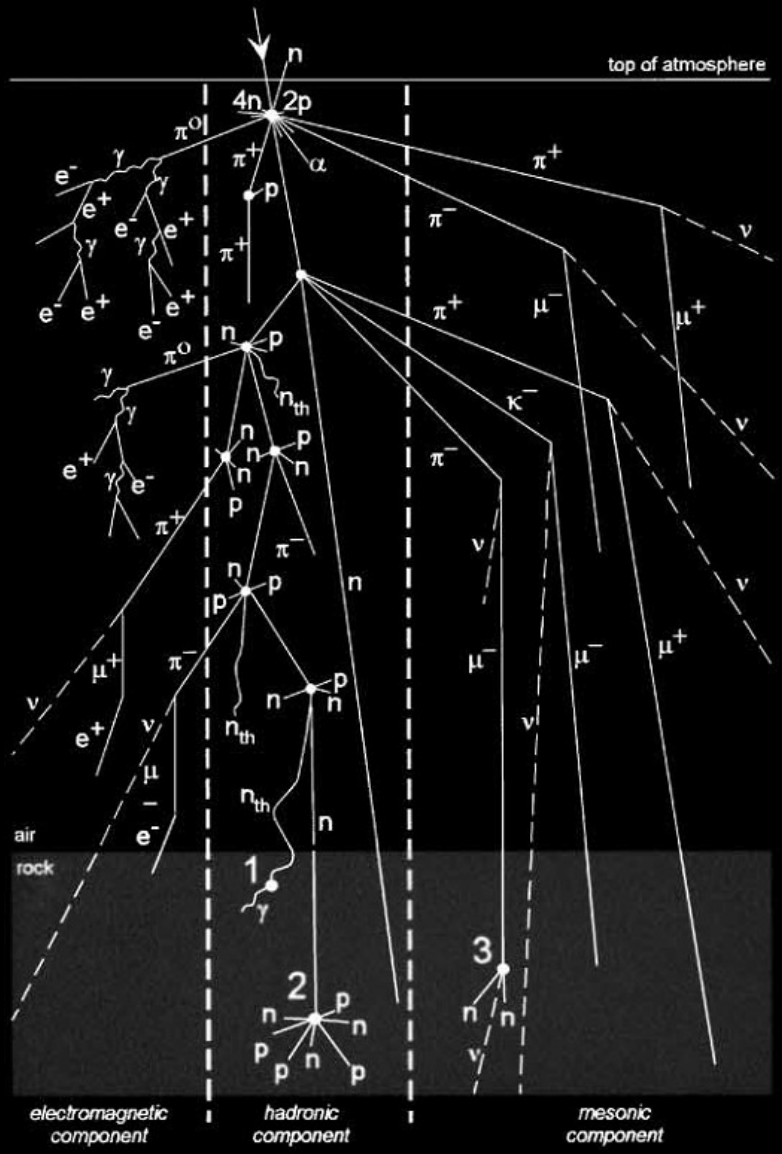

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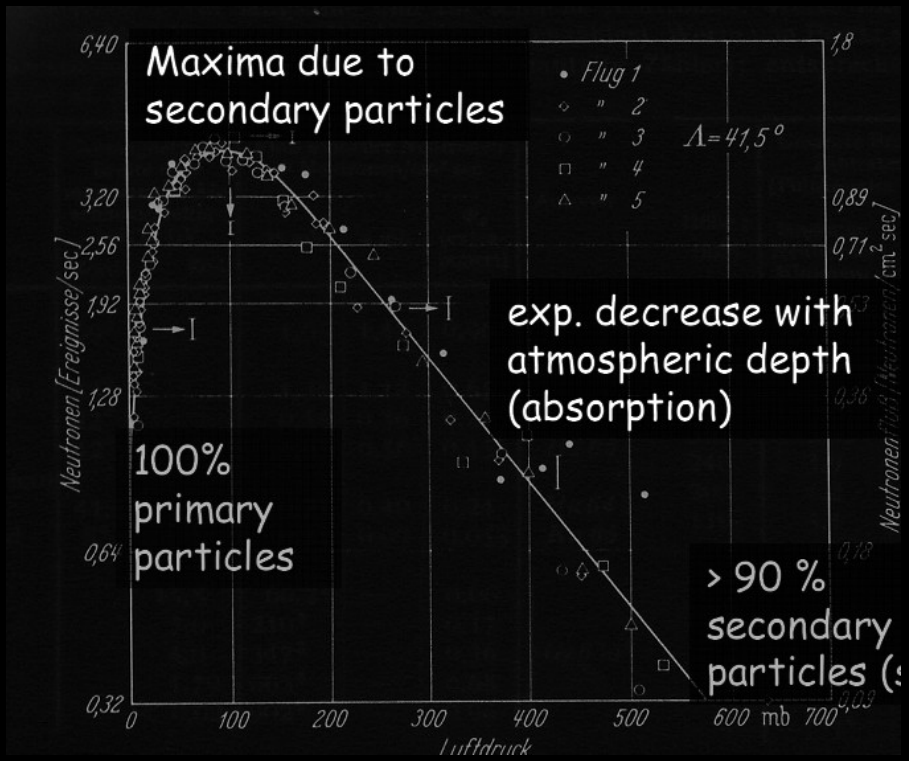
  - However: muons also produce ^{205}Pb

Muons are attenuated with depth



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  - → So: the mine must be deep enough

The Allchar mine is only 120 m deep

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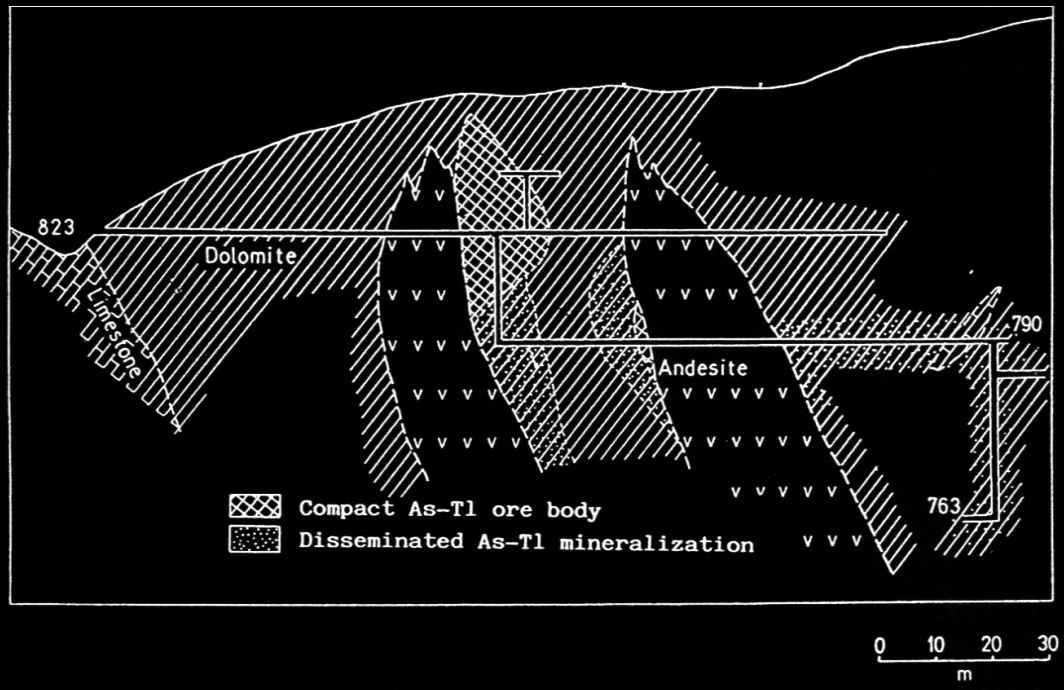
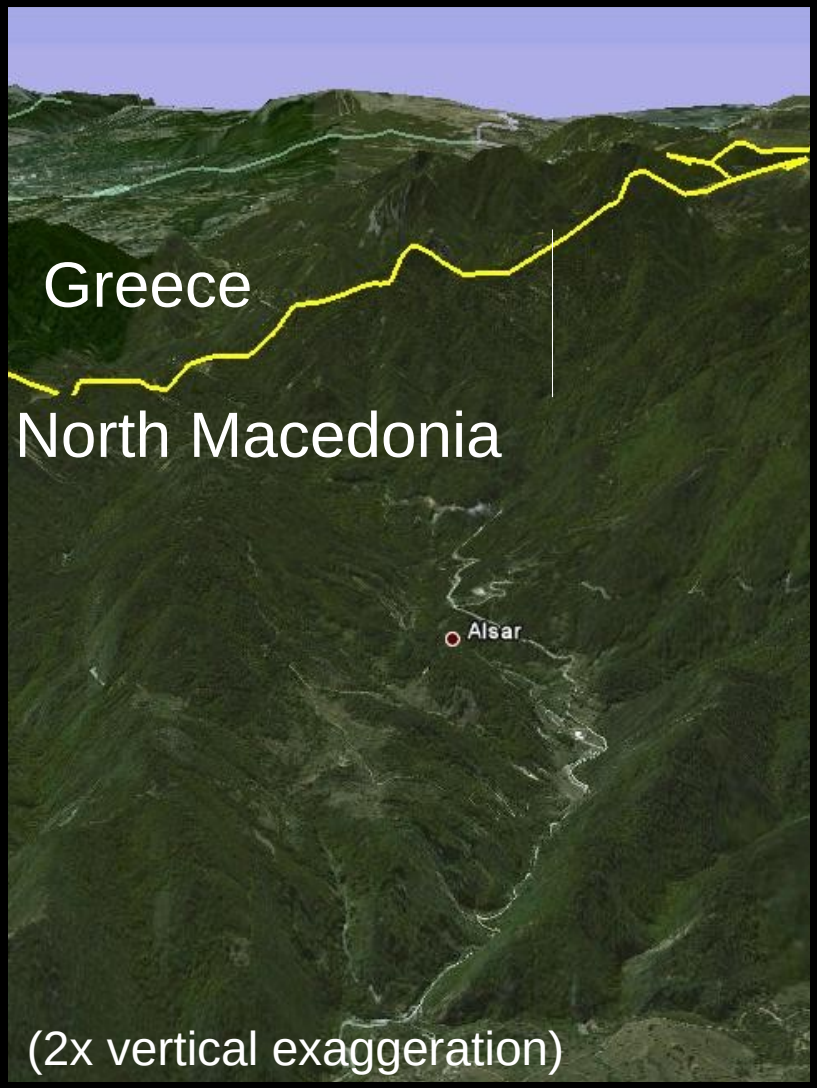


Pavícević (1994)

Erosion rates in Allchar are probably high



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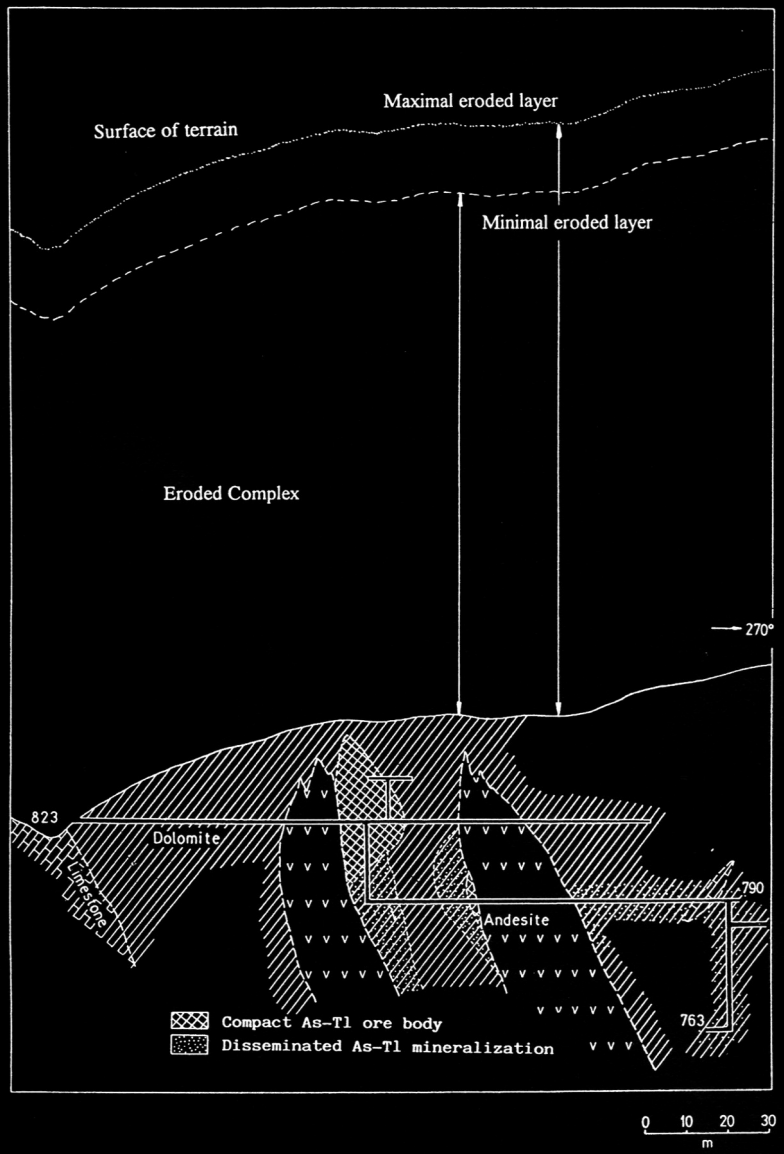
  - → However: Allchar is located in the mountains

High erosion rates => greater depths in the past



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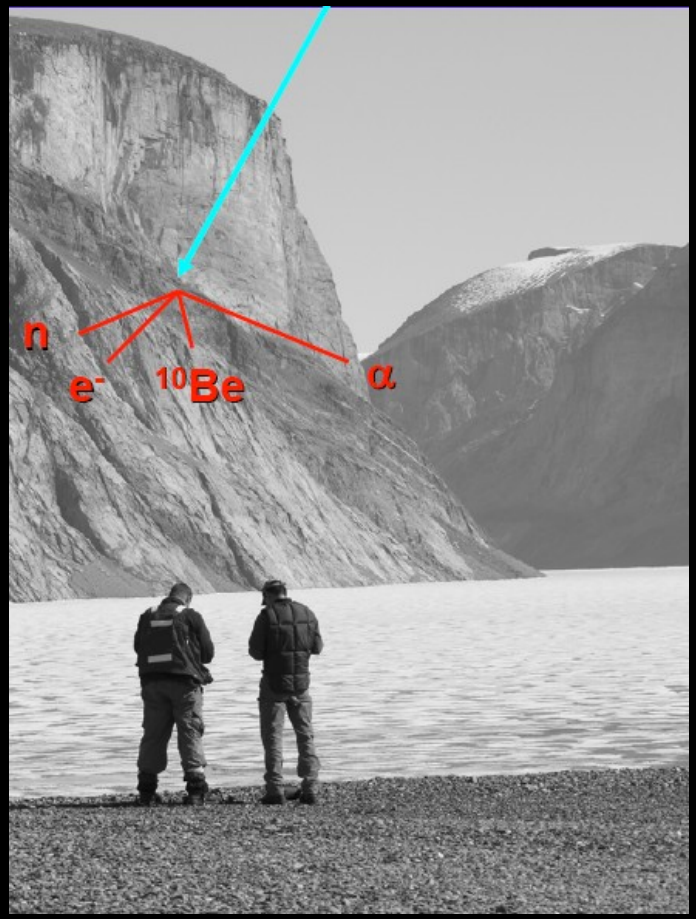
Pavícević (1994)

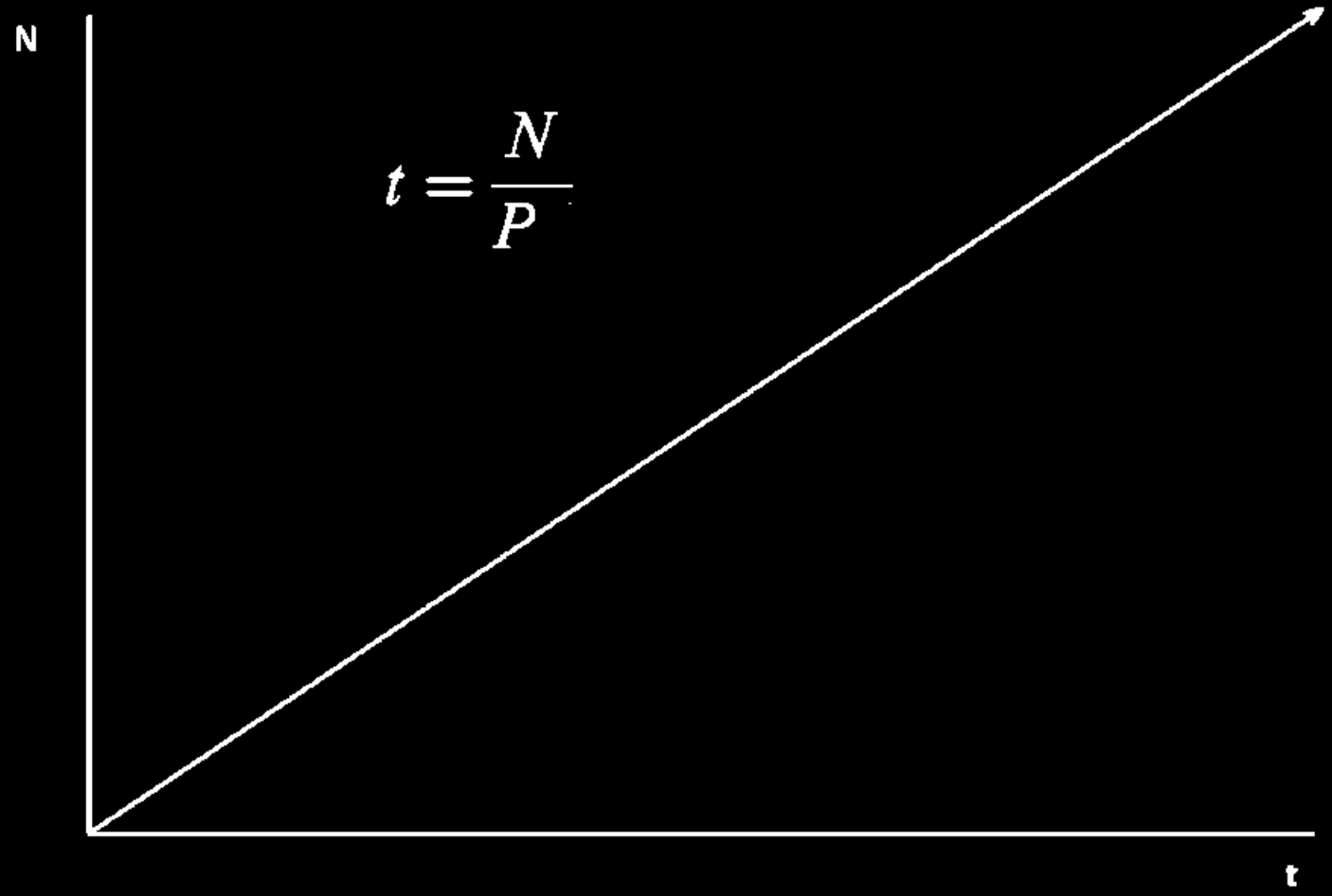
Interlude: spallation products of cosmic ray neutrons and muons

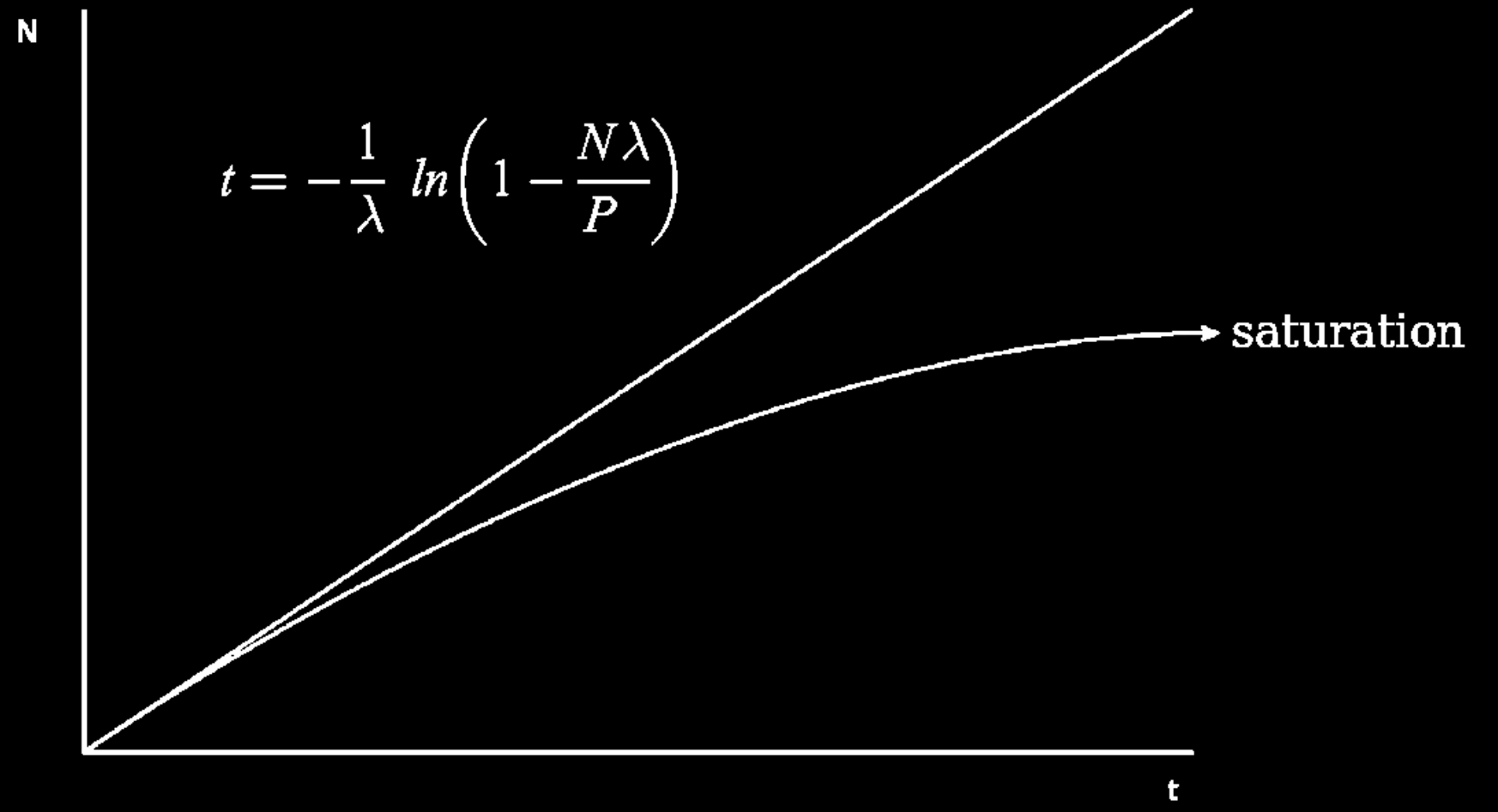


Nuclide	Lifetime	Reaction types and primary targets	Primary target minerals
^{3}He	stable	*Spallation on:* O,	Ol, Pyx, Hbl, Gnt
^{21}Ne	stable	*spallation:* Mg, Na, Al, Fe, and Si	Qtz, Ol, Gnt. Plag?
^{10}Be	2.2 Ma	$^{16}O(n,4p3n)^{10}Be$ $^{28}Si(n, x)^{10}Be$	Qtz, Ol, Mgnt, Plag?
^{26}Al	1.0 Ma	$^{28}Si(n,p2n)^{26}Al$	Qtz
^{36}Cl	430 kyr	$^{40}Ca(n,2n3p)^{36}Cl$ $^{39}K(\mu^-,p2n)^{36}Cl$ $^{40}Ca(\mu^-,\alpha)^{36}Cl$ $^{35}Cl(n,\mu)^{36}Cl$	Spallation tgt: K-spar, Plag, Calcite Thermal neutron activation tg: ^{35}Cl
^{14}C	0.82 kyr	$^{16}O(n,2pn)^{14}C$	Qtz

Geomorphological applications of cosmogenic nuclides

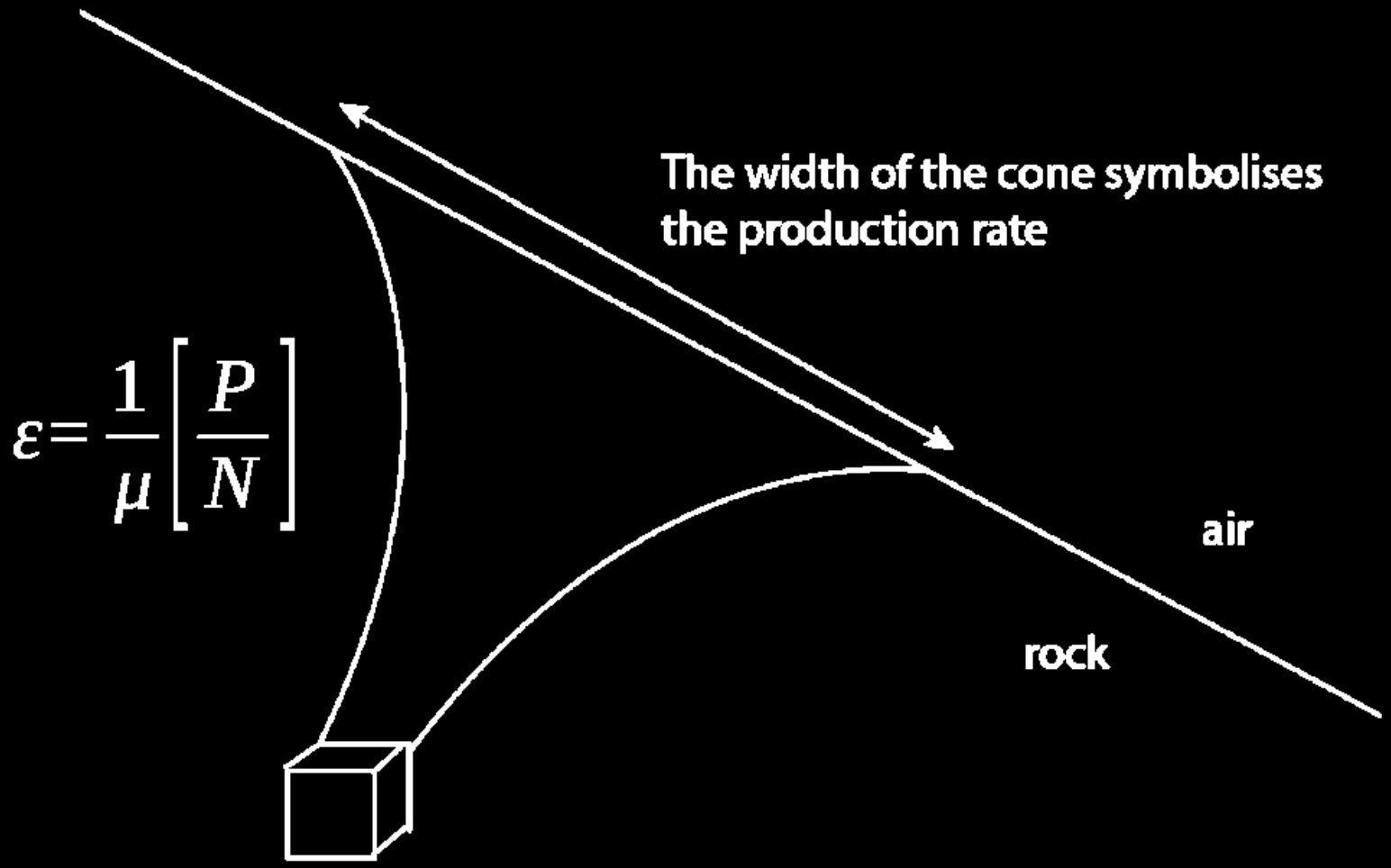
Stable nuclide, no erosion




N
$t = -\frac{1}{\lambda} \ln\left(1 - \frac{N\lambda}{P}\right)$
saturation
t

1859

2001



$$\varepsilon = \frac{1}{\mu}\left[\frac{P}{N}\right]$$

A cosmogenic erosion rate study from 1991

Z. Phys. A – Hadrons and Nuclei 341, 117–119 (1991)

Zeitschrift für Physik A Hadrons and Nuclei

Determination of erosion rates with cosmic ray produced $^{36}Cl^{\star}$

B. Dockhorn[1], S. Neumaier[1], F.J. Hartmann[1], C. Petitjean[2], H. Faestermann[1], G. Korschinek[1], H. Morinaga[1], and E. Nolte[1]

[1] Fakultät für Physik, Technische Universität München, W-8046 Garching, Federal Republic of Germany
[2] Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland

Received April 17, 1991; revised version July 3, 1991

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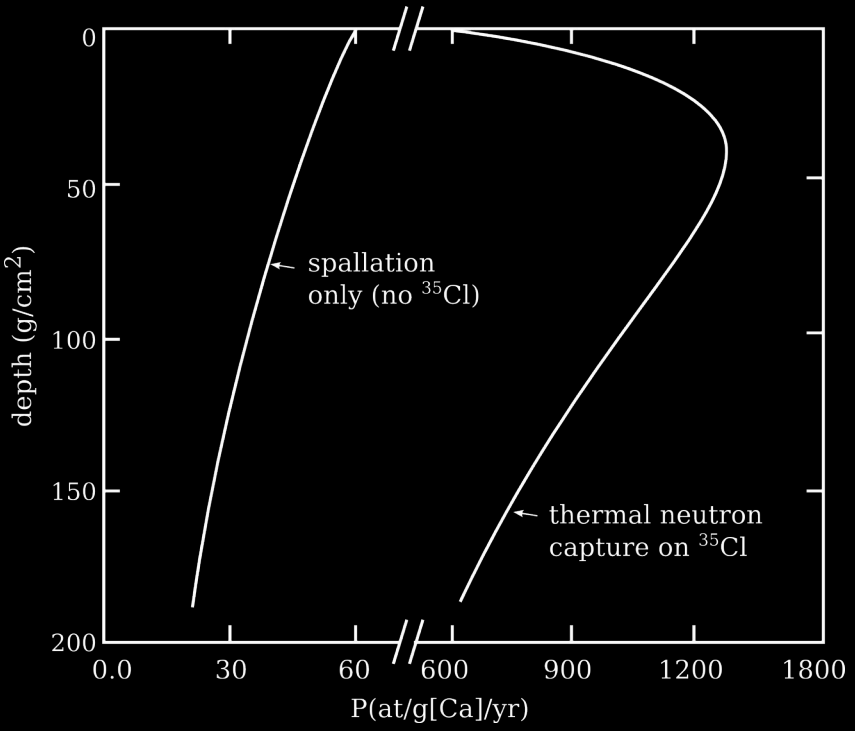
    So: it may have been deeper in the past
  - → Unfortunately, ^{36}Cl concentrations are high, implying low erosion rates.

The 1991 study may have been inaccurate



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→ Unfortunately, ^{36}Cl concentrations are high, implying low erosion rates.
→ However, Dockhorn didn't measure ^{35}Cl, so they may be underestimating erosion.

Second attempt at measuring the erosion rate

Lieber Pieter,

beiliegend sende ich Dir folgende Tabellen:

1. AMS 26Al VERA 2002
2. AMS 53Mn 2005
3. AMS 10Be PRIME Lab 28.07.2008
4. AMS 26Al und 10Be PRIME lab und VERA
5. AMS 26Al PRIME Lab 25.05.2009
6. AMS 26Al PRIME Lab 22.01.2010
7. GMI Untersuchungen 20.01.2009

Ich rufe Dich heute Nachmittag, noch einmal mit Dir die Tabelle durchdiskutieren.

Bis gleich wieder

Viele Grüsse

Miodrag

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→ So: M. Pavicevic repeats the cosmo dating.

Samples were collected in anthropogenically disturbed locations

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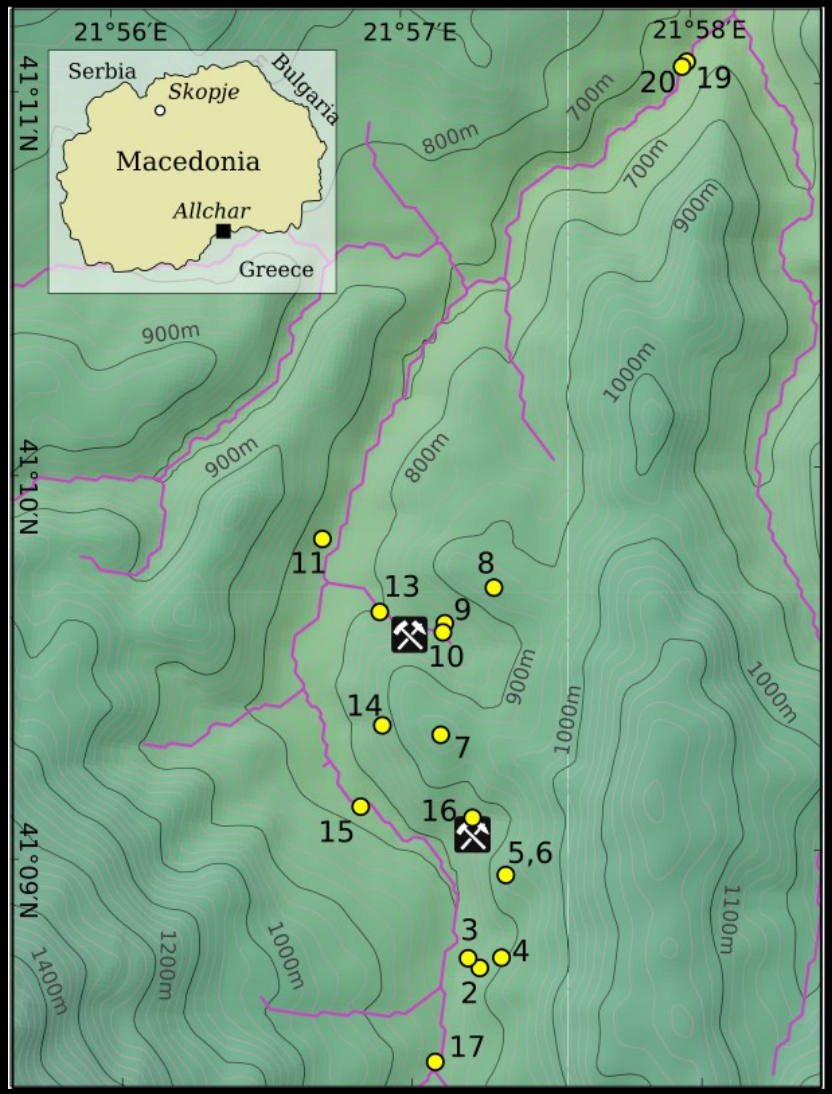
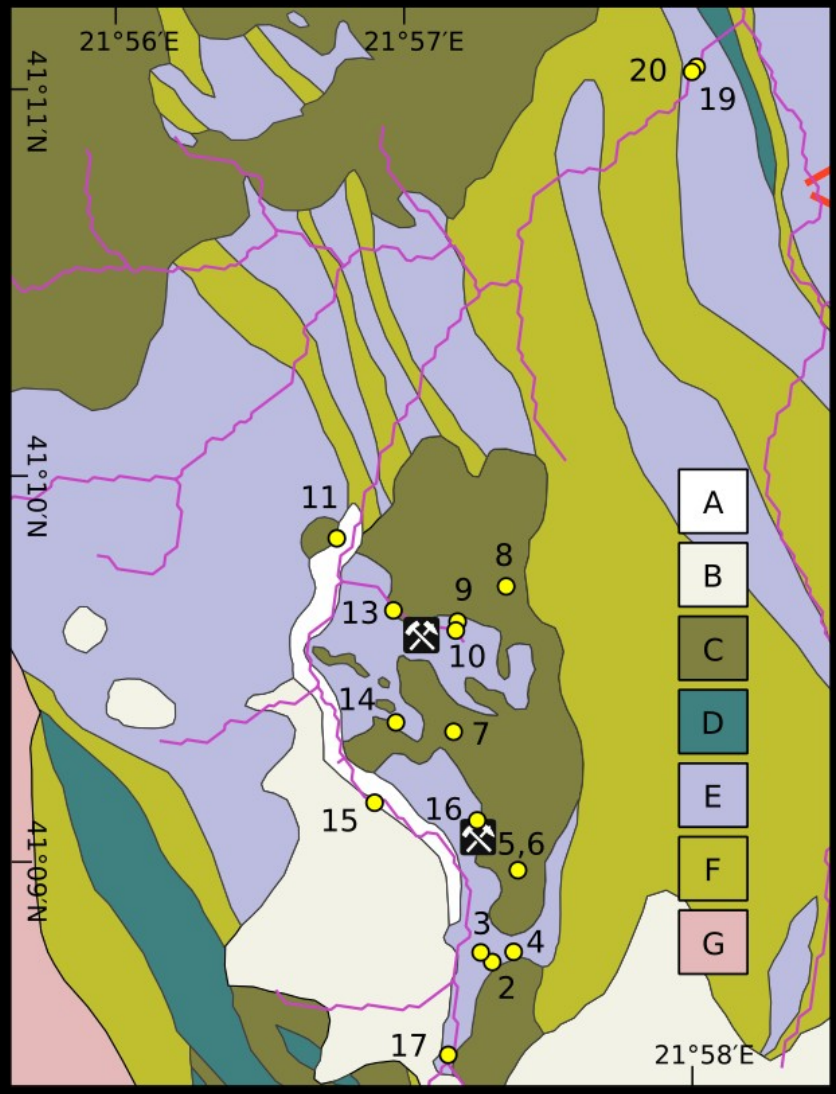
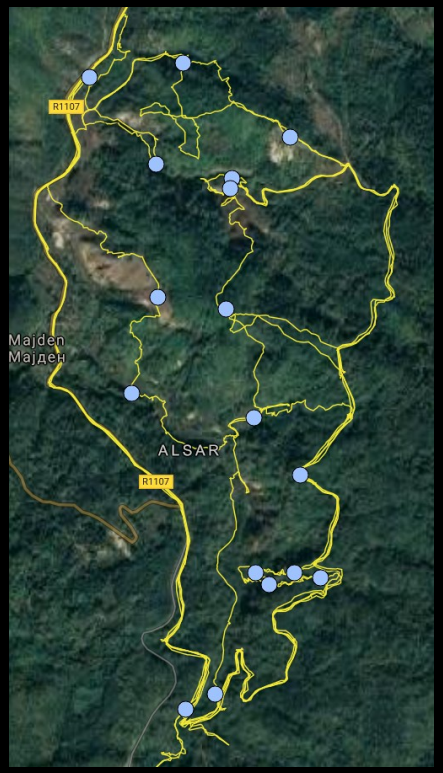
→ So: M. Pavicevic repeats the cosmo dating.
→ However, uses suboptimal sampling strategy.

Third attempt at measuring the erosion rate

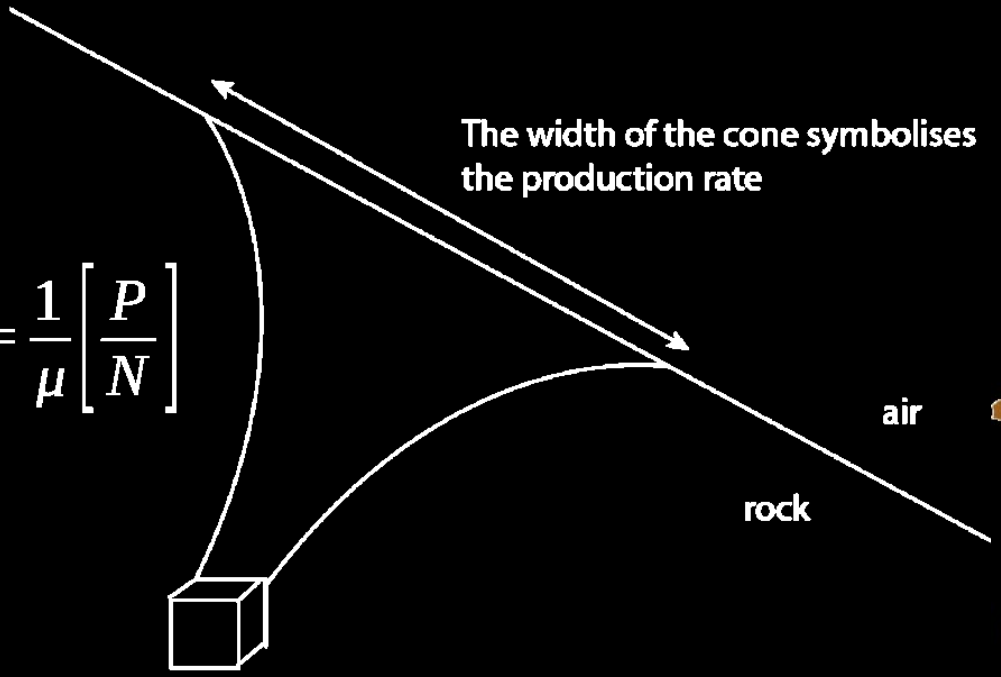


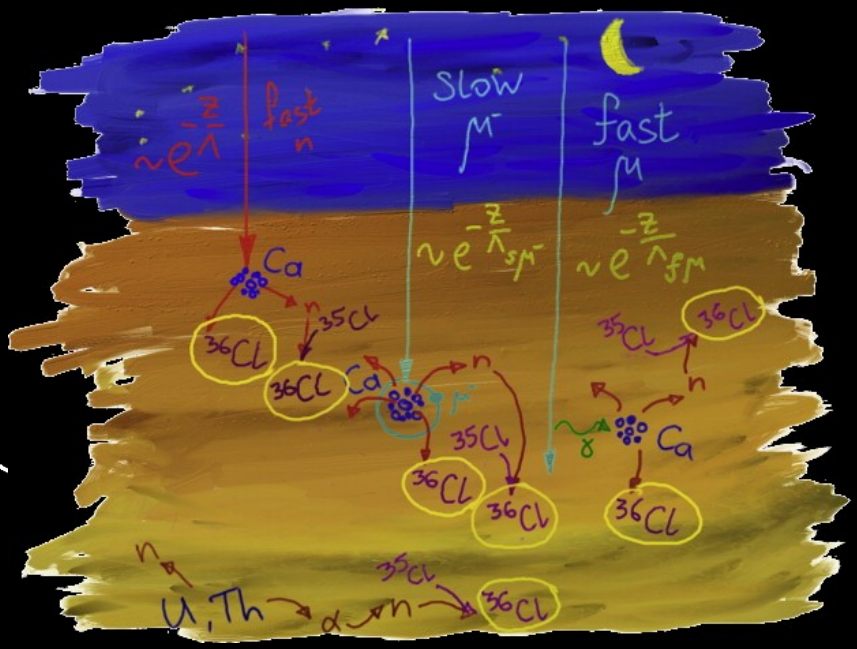


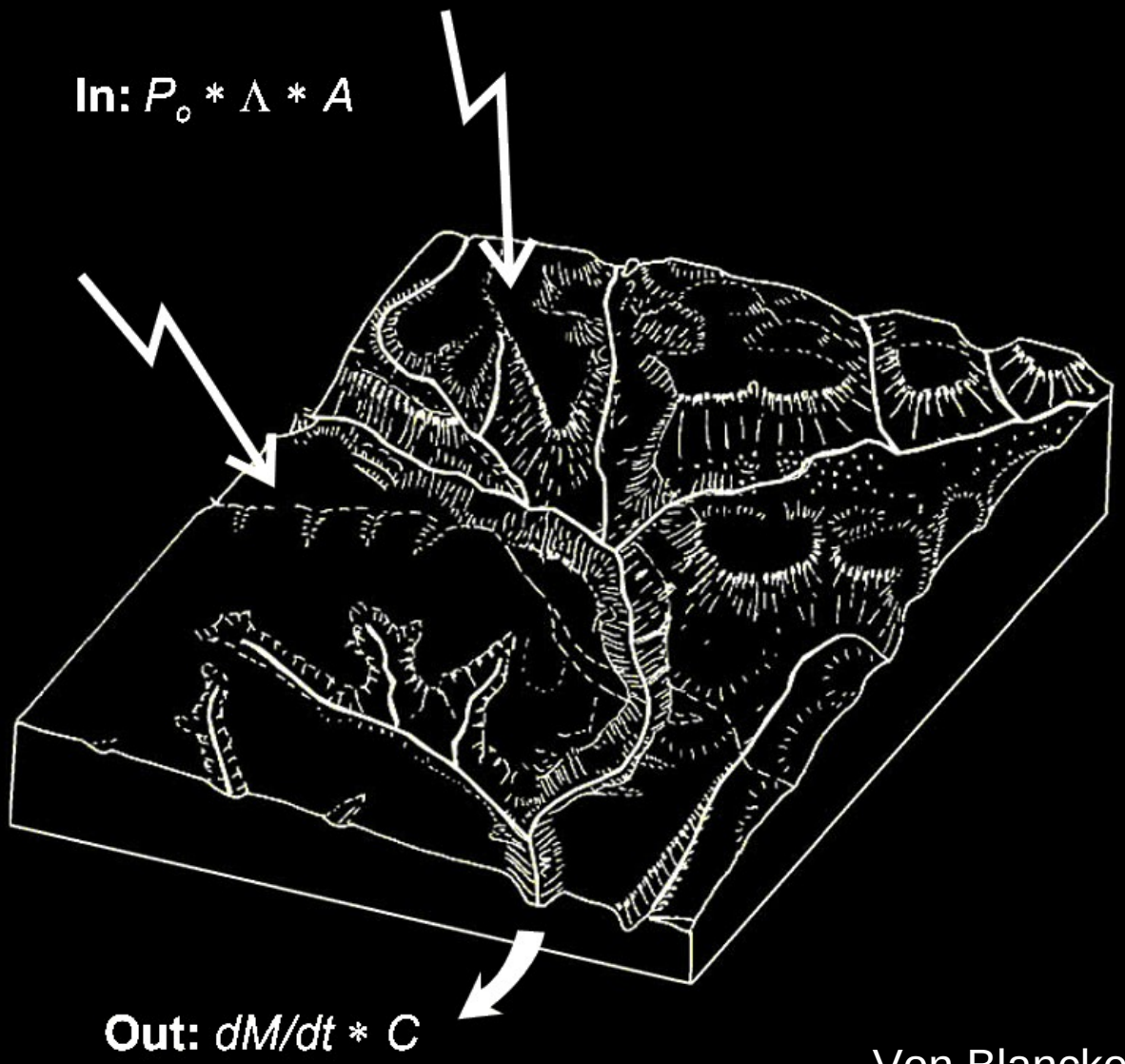
Field work in 2015: a variety of sampling strategies



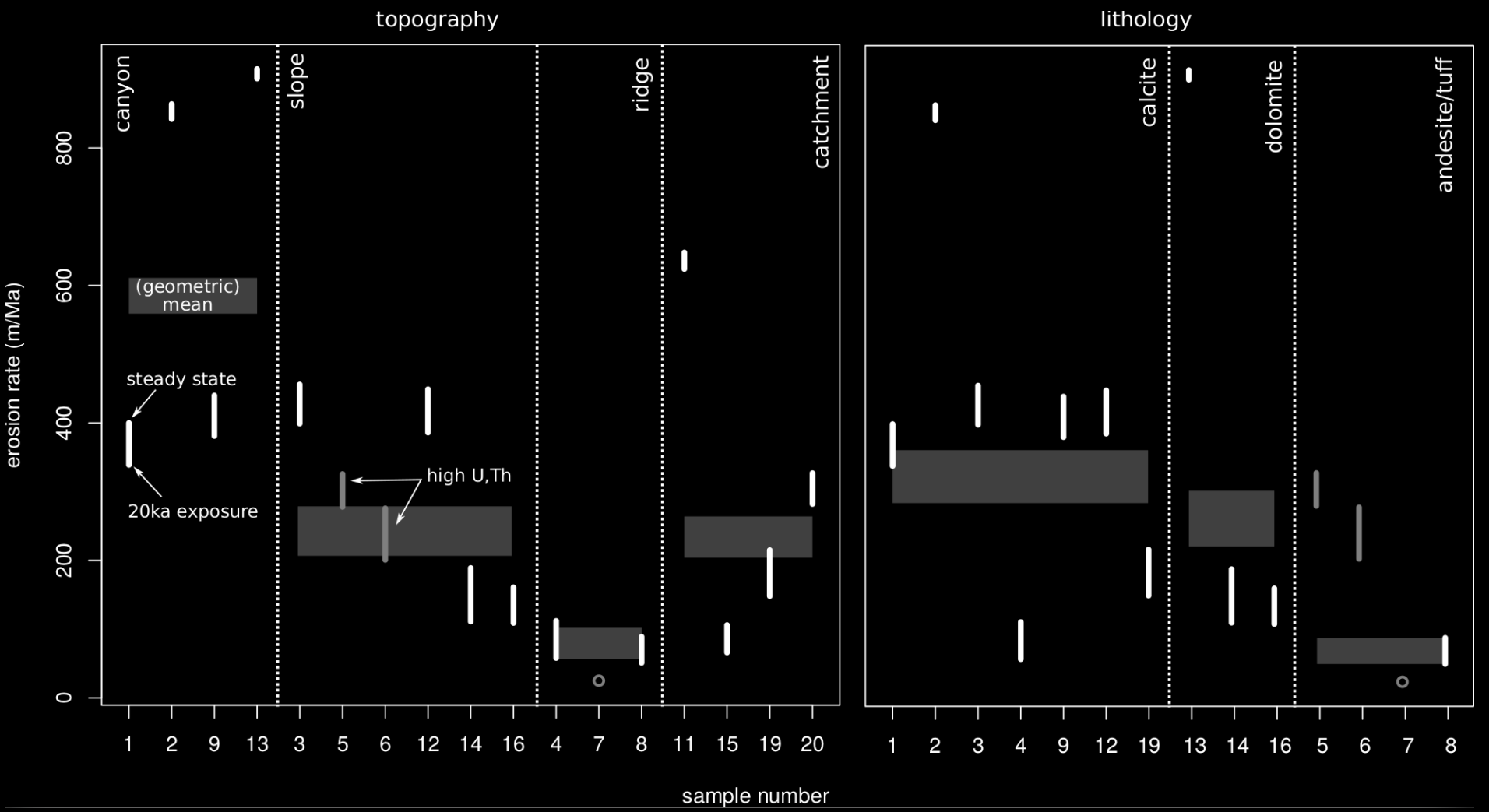
$$\varepsilon = \frac{1}{\mu}\left[\frac{P}{N}\right]$$

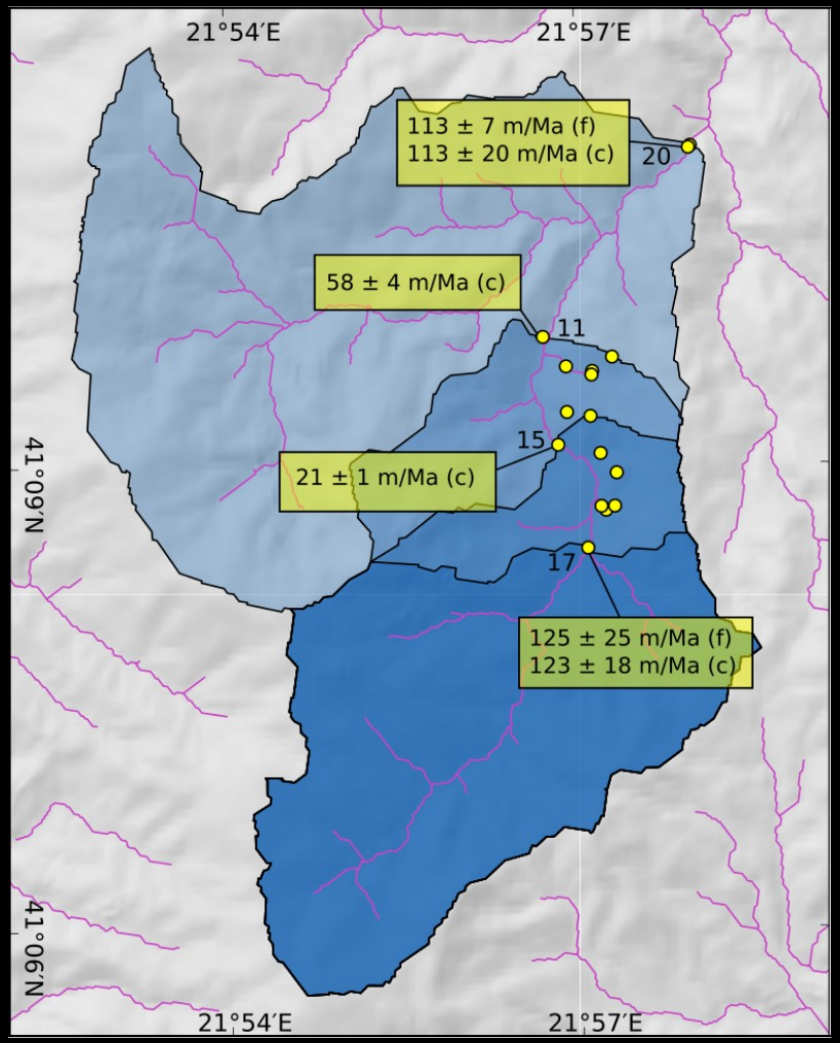






Von Blanckenburg (2005)


topography
lithology
canyon
slope
ridge
catchment
calcite
dolomite
andesite/tuff
(geometric) mean
steady state
20ka exposure
high U,Th
erosion rate (m/Ma)
0
200
400
600
800
1 2 9 13 3 5 6 12 14 16 4 7 8 11 15 19 20
1 2 3 4 9 12 19 13 14 16 5 6 7 8
sample number



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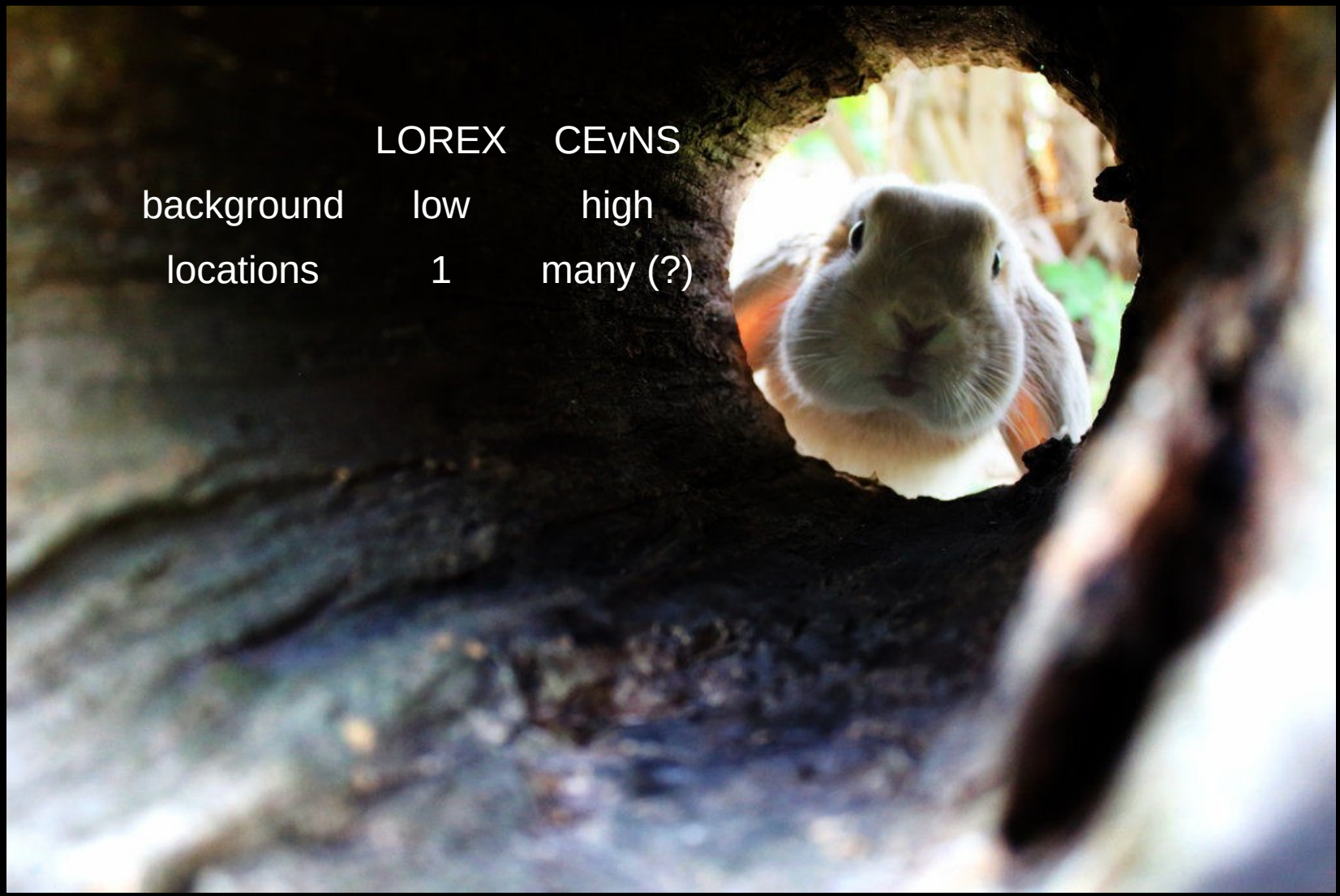
- However, Dockhorn didn't measure ^{35}Cl, so they may be underestimating erosion.
- So: Pavicevic repeats the cosmo dating.
- However, uses suboptimal sampling strategy
- Using better samples. LOREX does seem feasible!


LOREX CEvNS
background low high
locations 1 many (?)